PATENT SPECIFICATION

869,226

DRAWINGS ATTACHED.

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COMPLETE SPECIFICATION.

Improvements in or relating to Liquid Conductivity Measuring Cells.

We, ELECTRONIC SWITCHGEAR (LONDON) LIMITED, a British Company, of Works Road, Letchworth, Hertfordshire, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to liquid conductivity measuring cells such as are employed in apparatus for measuring liquid conductivities generally and in particular in apparatus for continuously monitoring the condition of a liquid supply in industrial equipment, for instance, a boiler feed-water supply.

Hitherto liquid conductivity measuring cells have been constructed mainly of glass, usually in the form of a tube with radial apertures therethrough and within which are disposed two spaced electrodes. Ideally, these electrodes should be of accurately predetermined area and at an accurately predetermined spacing distance apart. For example, to measure the conductivity of a standard unit of 1 cubic centimetre of liquid two parallel square plates exactly 1 centimetre side and exactly 1 centimetre apart are required. In practice it is not feasible to construct such known devices to have a particular exact area of electrode and electrode spacing distance and in consequence each individual cell, after manufacture, has to be measured against a standard and provided with a constant factor number which is subsequently used in calculations to modify any measurements which are made with the cell. While such individual cell calibration and the need for employment of the determined constant factor number in subsequent calculations may not be of undue disadvantage in laboratory use, it becomes extremely disadvantageous in industrial applications where the substitution or replacement of one cell by another, on the occasion of breakage or the like, can render the whole of the monitoring equipment useless until it has been readjusted in accordance with the particular constant value of the new cell. A further disadvantage of existing, mainly glass, devices is their high cost and extreme fragility especially to mechanical damage by mis-handling and/or thermal shock while in use.

The object of the present invention is to provide a simplified and cheapened construction of such conductivity measuring cells and in accordance with the broadest aspect of the invention the cell comprises at least two separate carbon electrodes embedded within a body of suitable insulating material, such as a mouldable plastic material, such carbon electrodes being so arranged that surface areas thereof are exposed as parts of a machined surface, such as that of a bored hole, made on or in the body of insulating material.

In order that the nature of the invention may be more readily understood a number of embodiments thereof will now be described in greater detail with reference to the drawings accompanying the Provisional Specification and also with reference to the drawings accompanying the present Complete Specification.

In the Provisional Specification drawings:—

Figure 1 is an axial cross-section through a mould device employed in forming a conductivity measuring cell according to the invention;

Figure 2 is an elevational view of the moulded article as removed from the mould of Figure 1; while

Figure 3 is an elevational view of the completed cell derived from the moulded article of Figure 2; while

Figure 4 is a fragmentary perspective view illustrating a modification.

In the Complete Specification: —

Figure 5 shows in axial cross-section another form of conductivity measuring cell embodying the invention and adapted for installation in a continuous liquid flow line of an industrial equipment;

Figure 6 is an end view of the cell shown in Figure 5;

Figure 7 is an axial cross-section of a laboratory type cell derived from the cell shown in Figure 5 with the aid of additional parts; while

Figure 8 is an axial cross-section through a further embodiment of the invention.

Referring first to Figures 1, 2 and 3, one method of manufacturing a cell of simple form in accordance with the invention will first be described. Use is made of a mould, conveniently formed as two similar halves, defining therein a chamber 14 which is of circular cross-section and which leads at one end into an enlarged region 15 having thread-forming surfaces therearound. This region 15 leads in turn to a still larger diameter cap-forming region 16.

A single short length of carbon rod 10, Figure 1, of accurately known diameter is first provided at each end with an attached electrical connecting wire 11 such as by copper plating the two ends of the rod and then soldering the two wires respectively thereto. This rod 10 with its attached wires is then positioned within a transverse aperture 12 formed in a short post 13 of any suitable material, e.g., a moulded plastic material, and the latter then placed at the end of the mould chamber 14 opposite that of the regions 15 and 16 by location within a subsidiary locating hole or recess within the mould. When properly positioned the rod 10 lies parallel with the adjacent end surface of the chamber 14 and at a given distance therefrom. The rod also lies so that its axis coincides with a diameter of the chamber 14.

Suitable moulding material, preferably in liquid or semi-liquid form, is then introduced into the interior of the mould, i.e., into chamber 14 and regions 15, 16, and is caused to set. Thereafter, the moulded body removed from the chamber has the form shown in Figure 2 consisting of a cylindrical part 19 having an enlarged screw-threaded region 17 at one end, the latter in turn leading to a still larger diameter cap 18. The connecting wires 11 from the opposite ends of the carbon rod 10 are embedded within the material of the moulded body and emerge from the outer end surface of the cap 18. The post 13 is, at this time, still embedded within the moulded body.

An axial hole, as shown at 20 in Figure 3, is now drilled in the body part 19 from the end 21, this hole being arranged so that its axis is at right angles to the length of the rod 10 and so that such axis passes precisely through the axis of the rod. The hole is of appreciably larger diameter than the rod 10 whereby such rod is separated into two portions 10*a*, 10*b*, the cross-sectional exposed inner end surfaces of which are respectively located in and are contiguous with the opposing side regions of the drilled hole. The hole is continued along the length of the part 19 to a depth considerably greater than that of the position of the carbon rod 10 and transverse holes 22 are then provided in the body 19 in the vicinity of the inner end of the hole 20 thereby to provide a number of flow conduits for permitting the liquid whose conductivity is to be measured to flow past the exposed surfaces of the electrodes 10*a*, 10*b*. The diameter of the hole 20 is preferably such that the post 13 is completely removed.

As the cross-sectional area of the carbon rod is accurately controllable and is known before moulding, correspondingly accurate control of the eventual cell characteristics is obtainable merely by accurate control of the diameter of the drilled hole 20.

As a moulding material for the insulating body one of the casting resins of the epoxy group, e.g., that known under the Registered Trade Mark "Araldite", is preferably employed as such materials are substantially inert to most liquids likely to be used with the device.

As an alternative to the employment of direct moulding of the carbon rod 10 within the body material, a prefabricated body of suitable insulating material may be provided and a first diametral hole drilled therein for the reception of the carbon rod which is then placed in the hole and sealed in position by plugs of insulating material, such as "Araldite", at each end. Therefore, a central axial hole is provided as already described with reference to Figure 3 in order to separate the carbon rod into two portions and further transverse holes made to communicate with the drilled central hole so as to provide liquid flow facilities.

An alternative arrangement is shown in Figure 4 where the embedded carbon rod 10 is divided by means of a transverse slot 24 of known width made in the end of the insulating body containing the carbon rod so as to divide the latter into its separate parts 10*a* and 10*b*.

Figure 5 shows a further embodiment of a preferred form of the invention in which

the electrodes are in the form of three carbon rings 27, 28, 29 held in axially spaced relationship and embedded within a body 30 of moulded plastic material so that their inner surfaces form parts of a bore 31 passing through the body 30.

In the preferred method of manufacture of this particular embodiment three carbon rings (or discs) 27, 28, 29 of accurately known thickness are first each provided with electrical connections as by copper plating a part or a whole of their peripheral outer surfaces and then soldering wires thereto. These rings are then secured together in accurately known axial spacing relationship by means of insulating spacer elements 32 which may again be of ring or disc form and of suitable moulded plastic material. The securing of the carbon rings to the spacer elements may be effected by means of any suitable adhesive such as an "Araldite" compound. The two outer carbon rings 27 and 29 are interconnected electrically by connecting their respective connecting wires to one external terminal 33 while the central carbon ring 28 has its connecting wire connected to a second external terminal 34. The assembled carbon electrodes and spacer elements are then supported within a mould of suitable shape along with the metallic terminal spills which are to form the eventual external electrical connection terminals. Moulding material is then introduced and caused to set to form the body 30 of the shape as shown whereafter an axial hole along a line coincident or substantially coincident with the common axis of the carbon electrodes and their associated spacer elements embedded within the moulded block, is drilled or otherwise machined right through the block from one end to the other to form the bore 31. The opposite outer ends of this central hole are then enlarged and screw threaded as shown at 35 and 36 for connection to conduit or like means of an industrial equipment.

The diameter of the bore 31 is accurately controlled so that the cell, after manufacture, has the required characteristics determined by the exposed area of each of the carbon electrodes and their accurately controlled physical spacing distance.

At one side the body 30 is formed with a short extension 37 provided with tapped apertures therein for receiving securing screws 38 while on the opposite side such body has a rather longer extension 39 upon which are formed integrally moulded posts 40 for housing the spills for the terminals 33 and 34. These terminals may be covered by a removable cap 41 as shown in chain dotted lines.

The advantage of the cell construction shown in Figures 5 and 6 is that the actual position of the hole forming the bore 31 need not be so accurately controlled whereby its axis coincides precisely with the axis of the carbon electrodes 27, 28, 29 and the associated spacer elements. Provided such hole is formed with its axis at right angles to the planes of the various electrodes, the actual position of the hole within each electrode is not important.

A cell of the type shown in Figures 5 and 6 is particularly adapted to industrial use for incorporation in a liquid flow line such as that of a boiler water feed supply but it may readily be converted into a normal laboratory type cell as shown in Figure 7 by the addition of a closure plug 42 of moulded plastic material at its lower end and a filling plug 43 at its upper end. Such filling plug 43 preferably has an enlarged outer filling orifice 44 and may be provided with a suitable side entry hole 45 for the reception of a thermometer for temperature checking purposes.

Figure 8 shows a further embodiment of the invention comprising a cylindrical body part 50 of moulded insulating material within which are embedded three spaced carbon electrodes in the form of discs (or rings) 51, 52, 53 disposed parallel with one another and at accurately controlled axial spacing distances apart from each other. The insulating body 50 has an enlarged diameter cap 54 at one end which is arranged to be received within a seating 55 formed in a head portion 56 also of insulating material and provided with a reduced diameter screw threaded extension 57 adapted to receive a sleeve 58 of insulating material for covering the body 50 and its carbon electrodes thereby to form an annular liquid flow passage 59 past the electrodes. This sleeve is provided with a number of radial ports 60 near the end attached to the head portion 56. The cylindrical body 50 is held in position by means of a further removable gland member 61 having a central aperture 62 through which the outwardly extending connecting leads 63 from the carbon electrodes can pass.

The carbon electrodes 51, 52, 53 are generally similar to those shown in Figures 5, 6 and 7 and may be of either disc or ring form and of accurately controlled axial thickness. They may either be held in their requisite accurately controlled axially spaced positions by suitable jig means during moulding or, alternatively, initially secured to each other by means of separate insulated spacing rings as in Figures 5, 6 and 7. Each carbon disc or ring is provided with two spaced apertures 63 for permitting the passage of the necessary electrical connecting wires therethrough with the aid of insulating tubes 64. The disc or rings are connected as in the case of Figures 5, 6 and 7 with the central ring or disc 52 joined to one terminal wire and the two flanking rings or discs 51,

53 joined together and to the other terminal wire. After moulding in position the external surface of the cylindrical body 50 and the integrally moulded carbon electrodes is subjected to a machining operation to cause it to have a predetermined and accurately controlled diameter which, in conjunction with the controlled thickness and axial spacing of the carbon electrodes, ensures that the subsequent cell has a predetermined characteristic.

The use of three separate spaced electrode elements, such as the rings 27, 28 and 29 of Figures 5 and 6 or the discs 51, 52 and 53 of Figure 8, with the two outermost elements interconnected as one electrode and the intermediate element forming the other electrode is particularly advantageous when the device is used in association with a liquid flow pipe of metal. By arranging that such outermost electrode elements are at the same potential, e.g. earthed, as the pipework any current conduction between them (with its consequent modification of the effective constant value of the cell) is avoided. To facilitate proper connection, the two cell terminals are appropriately marked.

Various other modifications will be obvious to those skilled in the art and are intended to be included within the scope of the invention. For example, instead of employing a single carbon rod which is subsequently divided as described with reference to Figures 1, 2, 3 and 4, separate portions of carbon rod each provided with a connecting wire may be used and moulded in position so as to project outwardly on diametrically opposite sides of a rod-like body of insulating material which is then finished externally such as by turning or grinding to a given diameter and afterwards positioned within a suitable liquid confining means such as a surrounding cylinder. Another modification may utilise a plurality of separate sections of a carbon cylinder in the formation of the necessary electrodes. For instance, four curved part-cylindrical portions may be arranged and moulded within a body of moulded insulating material at positions which are 90° displaced from one another. A central axial hole may then be drilled in the material whereby the surface of such hole includes a part of each of the separate carbon plates in the form of four separate arcuate surfaces of known size at angularly displaced positions around the wall of the hole. Again, by accurate control of the size of the hole and the thickness of the plates, so the characteristic of the cell can be given a desired predetermined value. The various sections of the carbon body may initially be united as a one-piece element by a part thereof which is subsequently removed by the drilling operation.

The cells according to the invention, in addition to being robust mechanically and insensitive to thermal shock conditions, are extremely cheap to construct compared with those of more conventional form and, moreover have the advantage that each cell made to given dimensions is sufficiently similar to other cells made to the same dimensions as to become interchangeable therewith without any necessity of readjusting the associated apparatus.

WHAT WE CLAIM IS:—

1. A liquid conductivity measuring cell which comprises at least two carbon electrodes embedded within a body of insulating material, such carbon electrodes being arranged so that surface areas thereof are exposed as parts of a machined surface made on or in said body of insulating material.

2. A liquid conductivity measuring cell according to Claim 1 in which said carbon electrodes are arranged so that the machined surface areas thereof form parts of the internal surface of a hole in said body of insulating material.

3. A liquid conductivity measuring cell according to Claim 1 in which said carbon electrodes are arranged so that the machined surface areas thereof form parts of an external surface of said insulating body.

4. A liquid conductivity measuring cell according to Claim 2 comprising at least two axially spaced carbon rings embedded in a body of insulating material and a machined bore in said body passing axially through each of said rings.

5. A liquid conductivity measuring cell according to Claim 2 in which said hole is in the form of a blind borehole having near its inner end radial ports communicating with the external surface of said body.

6. A liquid conductivity measuring cell according to Claim 3 comprising at least two carbon discs or rings embedded within a body of insulating material at predetermined axial spacing distances apart, said body of insulating material having a machined external surface of predetermined cross-sectional dimension.

7. A liquid conductivity measuring cell according to Claim 4, 5 or 6 which comprises three carbon rings or discs, the two outer rings or discs being electrically connected to one cell terminal and the central ring or disc to another cell terminal.

8. A liquid conductivity measuring cell according to Claim 2 comprising a body of insulating material, a bore of known diameter in said body and diametrically opposed carbon electrodes also embedded in said body with exposed surfaces contiguous with said bore at diametrically opposed positions therein.

9. A method of manufacturing a liquid conductivity measuring cell which comprises

embedding a plurality of carbon electrode forming elements of predetermined dimension within a body of moulded electrical insulating material so that said carbon elements have a predetermined spacing relationship to each other and then executing a machining operation on said body and said embedded carbon electrode members to form a surface of predetermined physical dimensions having said carbon electrode elements exposed as contiguous parts thereof.

10. A method of manufacturing a liquid conductivity measuring cell which comprises the steps of embedding a carbon electrode forming member within a body of moulded electrical insulating material and then executing a machining operation upon the body of said insulating material and said embedded carbon electrode member to divide such member into two parts having exposed surfaces contiguous with the machined surfaces of said body.

11. A liquid conductivity measuring cell substantially as described with reference to Figures 1, 2 and 3, or Figure 4 or Figures 5 and 6 or Figure 7 or Figure 8 of the drawings.

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PROVISIONAL SPECIFICATION.

Improvements in or relating to Liquid Conductivity Measuring Cells.

We, ELECTRONIC SWITCHGEAR (LONDON) LIMITED, a British Company, of Works Road, Letchworth, Hertfordshire, do hereby declare this invention to be described in the following statement:—

This invention relates to liquid conductivity measuring cells such as are employed in apparatus for measuring liquid conductivities generally and in particular in apparatus for continuously monitoring the condition of a liquid supply in industrial equipment, for instance, a boiler feed-water supply. One example of such continuous monitoring apparatus is described in our co-pending Application No. 37292/55.

Hitherto liquid conductivity measuring cells have been constructed mainly of glass, usually in the form of a tube with radial apertures therethrough and within which are disposed two spaced electrodes. Ideally these electrodes should be of accurately predetermined area and at an accurately predetermined spacing distance apart. For example, to measure the conductivity of a standard unit of 1 cubic centimetre of liquid, two parallel square plates exactly 1 centimetre side and exactly 1 centimetre apart are required. In practice it is not feasible to construct such known devices to have a particular exact area of electrode and electrode spacing distance and in consequence each individual cell, after manufacture, has to be measured against a standard and provided with a constant factor number which serves to modify any measurements subsequently made therewith. While such individual cell measurement and the need for employment of the determined constant factor in subsequent calculations may not be of undue disadvantage in laboratory use, it becomes extremely disadvantageous in industrial applications where the substitution or replacement of one cell by another, on the occasion of breakage or the like, can render the whole of the monitoring equipment useless until it has been readjusted in accordance with the constant value of the new cell. A further disadvantage of existing, mainly glass, devices is their high cost and extreme fragility especially to mechanical damage by mis-handling and/or thermal shock while in use.

The object of the present invention is to provide a simplified and cheapened construction of such conductivity measuring cells and in accordance with the broadest aspect of the invention the cell comprises a pair of carbon electrodes embedded within a body of suitable insulating material, such as a mouldable plastic material, the electrodes being so arranged that the area of the surfaces thereof exposed to contact with the liquid and the physical spacing distance between such surfaces are accurately controllable during manufacture.

One particular method of manufacturing a cell according to the invention will now be described with reference to Figures 1—3 of the accompanying drawings. A single short length of carbon rod 10, Figure 1, of accurately known diameter is first provided at each end with a connecting wire 11, e.g. by copper plating the end of the rod and then soldering the wire thereteo. The rod is then positioned within a transverse aperture 12 formed in a short post 13 of suitable material, e.g. moulded plastic, and the latter placed at one end of a mould chamber 14 so that the rod 10 lies substantially parallel with a surface of the chamber and at a given spacing distance therefrom. The chamber 14 is conveniently of circular cross-section in which case the rod 10 should be in a diametral plane of the chamber. The

opposite end of the chamber may be shaped as at 15 and 16 to provide a screw-threaded region 17 and a head ring 18 respectively on the eventual moulding, Figure 2. The mould may be of the usual two-part form. Suitable moulding material is then introduced into the chamber and caused to set. Thereafter the moulded body 19, Figures 2 and 3, is withdrawn from the mould chamber and a hole 20, Figure 3, is then drilled in the body 19 from the end 21. This hole is arranged so that its axis is disposed at right angles to the length of the carbon rod 10 and passes therethrough whereby the rod is separated into two portions 10*a*, 10*b*, the cross-sectional exposed inner end surfaces of which are respectively located in and are contiguous with the opposing side regions of the drilled hole. The hole is continued to a depth considerably greater than that of the carbon rod 10 and transverse holes 22 are then provided near the inner end of the hole 20 to provide flow conduits for the liquid whose conductivity is to be measured. The diameter of the hole 20 is preferably such that the post 13 is completely removed. The connecting wires 11 of the electrodes 10*a*, 10*b*, thus formed, are arranged to pass out of the opposite or head end of the moulded body.

As the cross-sectional area of the carbon rod 10 is accurately controllable and is known before moulding, correspondingly accurate control of the eventual cell characteristics is obtainable merely by accurate control of the diameter of the drilled hole 20.

As a moulding material one of the casting resins of the epoxy group, e.g. that known under the Registered Trade Mark "Araldite", is preferably employed as such materials are substantially inert to most liquids likely to be used with the device.

As an alternative to the employment of direct moulding of the carbon rod within the material, a prefabricated body of suitable insulating material may be provided and a first diametral hole drilled therein for the reception of the carbon rod which is then placed therein and sealed in position by plugs of material such as "Araldite". A central axial hole is thereafter provided as before to separate the carbon rod into two portions and further transverse holes made to provide the liquid flow conduit.

As an alternative to the provision of an axial hole to divide the embedded carbon rod, a transverse slot of known width may be made in the end of the insulating body as shown at 24 in Figure 4.

Other modifications will be obvious to those skilled in the art, for example, two separate portions of carbon rod, each provided with a connecting wire, may be moulded so as to project outwardly on diametrically opposite sides of a rod-like portion. The latter may then be finished externally as by turning or grinding to a given diameter and afterwards positioned within a suitable liquid confining means such as a surrounding cylinder. Another embodiment may utilise a plurality of separate sections of a carbon cylinder, for instance, four curved part-cylindrical portions which are arranged to be moulded within a body of moulding material at positions which are 90° displaced from one another; a central axis hole then drilled in the material whereby the surface of the hole passes through each of the separate carbon plates to provide four separate arcuate surfaces of known size at angularly displaced positions around the wall of the hole. Again by accurate control of the size of the hole, so the characteristics of the cell can be given a desired predetermined value. The various sections of the carbon body may, initially, be united as a one-piece element by a part which is later removed by the drilling operation.

Such cells, in addition to being robust mechanically and insensitive to thermal shock conditions, are extremely cheap to construct and, moveover, have the advantage that each cell made to given dimensions is sufficiently similar to other cells made to the same dimensions to become interchangeable therewith without the necessity of any adjustment of the associated apparatus.

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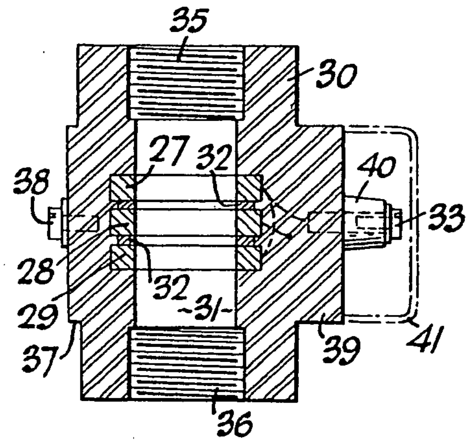
FIG.5.



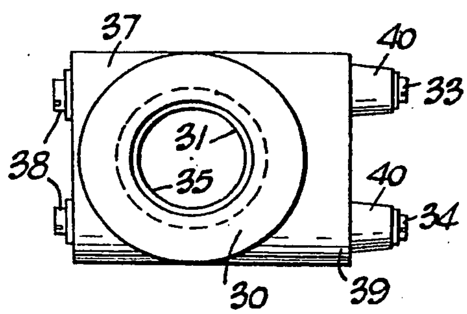


FIG.6.

FIG.7.

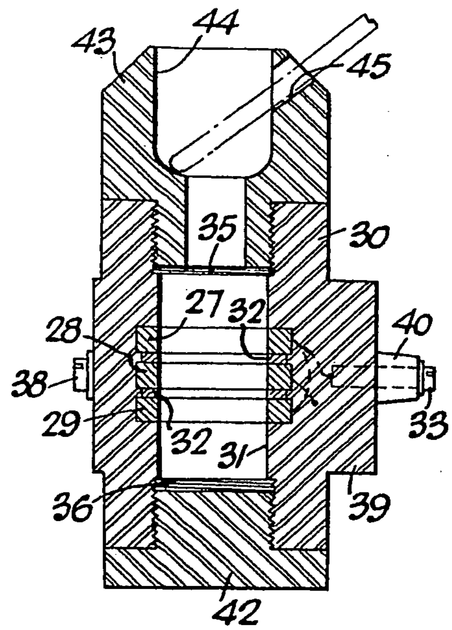
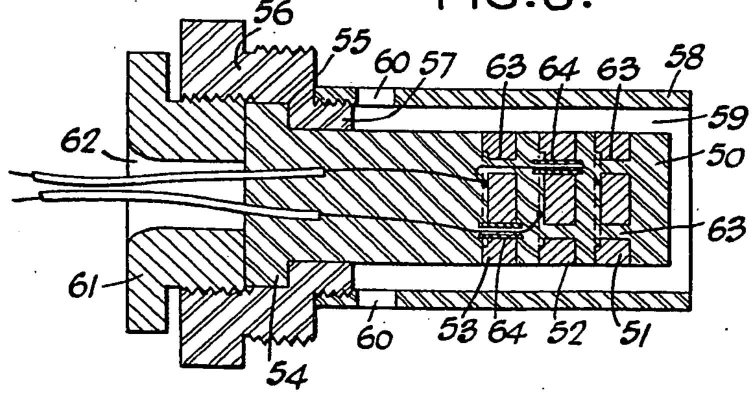


FIG.8.



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1 SHEET
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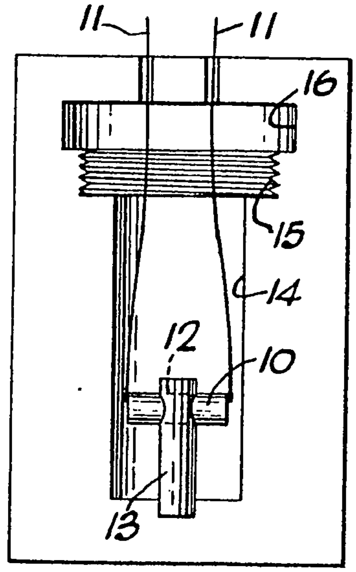

FIG.1.

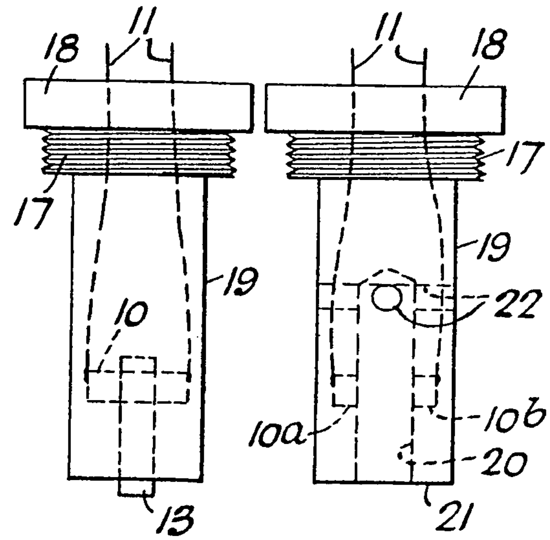

FIG.2. FIG.3.

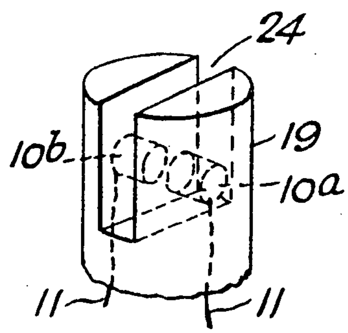

FIG.4.